Exploring e-readers to support clinical medical education: two case studies*† EC

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Question: Can e-readers loaded with medical textbooks and other relevant material benefit medical students, residents, and preceptors in clinical settings?

Settings: The settings are North Carolina community clinics served by Duke University Medical Center and St. Joseph's Hospital in Bryan, Texas, and Scott and White Memorial Hospital in Temple, Texas.

Methods: Duke University: Twenty second-year medical students and fourteen family medicine clerkship preceptors used Kindle e-readers in clinics during eight months of rotations. Students and preceptors provided feedback through an anonymous online survey. Texas A&M University: Nine fourth-year medical students in an elective compared medical textbooks in print, online, and on a Kindle. Six residents at a local hospital completed an anonymous online survey after a three-week loan of a Kindle loaded with medical textbooks.

Results: The e-reader's major advantages in clinical settings are portability and searchability. The selected e-reader's limitations include connection speed, navigation, and display. User preferences varied, but online resources were preferred. Participants suggested additional uses for Kindles in medical education.

Conclusions: The selected e-reader's limitations may be resolved with further development of the device. Investigation of other e-readers is needed. Criteria for evaluating e-readers in clinical settings should include portability, searchability, speed, navigation, and display. Research comparing e-readers and mobile devices in clinical education is also warranted.

INTRODUCTION

Patient care encounters often generate questions, either directly from the patient or from gaps in the clinician's knowledge or experience. A 2007 review of the literature indicated that physicians generate somewhere between 0.16 and 1.27 clinical questions per patient encounter [1]. Another study demonstrated that family medicine residents generate 1.3 questions per patient [2]. Medical students on clinical rotations likely have a similar, if not higher, rate of questions, given their relative lack of experience.

Multiple obstacles can impede the efficient and seamless acquisition of information in the clinical setting, such as resources that are physically distant, poorly organized, or not clinically oriented [3]. To facilitate better information usage, medical libraries offer electronic books and other resources that are accessible on laptop or desktop computers. Some resources are also available on mobile devices. The recent prominence of electronic book readers offers a potential solution for a portable and searchable electronic library in clinical settings.

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EC Supplemental Appendixes A and B are available with the online version of this journal.

The authors were unable to find any studies testing e-book readers in medical education. Several academic libraries have piloted circulation or classroom projects with e-readers [4, 5] or have tested multiple e-reader devices for evaluative purposes [6–8]. While not testing an e-book reader specifically, a study exploring nursing students' use of e-books on portable digital assistants (PDAs) indicated that handheld devices loaded with e-books were recommended for students and nursing staff for use in clinical care [9].

A search of the literature revealed numerous other studies exploring the role of handheld computers in medical education and clinical care and demonstrated the utility of these devices for accessing information for medical reference. One systematic review focused on hospital physicians' use of handheld computers and demonstrated that mobile handheld technology can improve access to information for physicians [10]. A recent systematic review of 67 studies testing handheld computers in medical education found that 60%–70% of students and residents used handhelds for educational purposes or clinical care and that electronic textbooks ranked highly among the most useful and most commonly accessed applications [11].

Electronic book sales, use, and acceptance are expected to climb dramatically in the next five years [12]. A number of studies in academic environments have investigated electronic books according to student preferences, usage rates, and the nature of e-book use [13–19]. Though usage rates and preferences vary, positive comments generally point to the searchability and the immediate access to information that these materials provide, as well as their suitability for reading small chunks of text [16, 18]. Negative

feedback generally centers on difficulty in navigation and downloading and a lack of awareness of available resources [13]. To make electronic books more accessible and to promote use, libraries have undertaken a number of projects, such as linking to e-books from the online catalog, including title or chapter-level search capability on the library's website; creating federated searching tools for e-books; or offering e-books on mobile devices [20–22].

To evaluate the potential of e-readers in meeting the information demands of students, residents, and clinicians in the clinical setting, two medical libraries piloted separate projects using e-readers. Upon hearing of each other's interest in exploring Kindle e-readers in clinical education, librarians from the two institutions connected and shared best practices as their projects evolved. The Amazon Kindle was of particular interest to the librarians involved because, among e-readers available at the time, it uniquely allowed easy access to electronic books, personal documents, and free basic wireless Internet. To the librarians, the combination of electronic books and documents and wireless access made the Kindle a potential tool for medical students and health care practitioners working in educational or clinical settings, particularly those that do not have their own wireless networks or multiple computers for access. The Duke University Medical Center Library project tested the selected e-reader as a point-of-care mobile device in primary care clinical settings. The Texas A&M University (TAMU) Medical Sciences Library (MSL) conducted an evaluative study of the selected e-reader to determine resident and medical student attitudes and preferences. While the projects are distinct in design and evaluation, they are reported together because they both tested the same e-reader, the Amazon Kindle, in medical education settings and drew similar conclusions.

DUKE UNIVERSITY MEDICAL CENTER LIBRARY

Setting

The Duke University Medical Center Library serves the medical center community of Duke University, a private institution in Durham, North Carolina. The library has a collection budget of more than $1.6 million and a collection of more than 247,000 volumes, 5,100 journal subscriptions, and 400 e-books. The library serves students, faculty, and staff at the school of medicine, school of nursing, physician assistant program, and physical therapy program, as well as the house staff, clinicians, and staff at the hospital and clinics. The school of medicine curriculum at Duke is structured differently from other medical schools because clinical clerkships occur in the second year, with the third year reserved for research projects.

The library conducted an eight-month project testing Kindles with second-year medical students and their preceptors in educational primary care settings in the family medicine clerkship. The primary objective was to explore whether the selected e-reader could improve access to medical information in clinical settings with little or no wireless or networked computer access. The library received funding for the project through an Express Outreach Project Award from the National Networks of Libraries of Medicine. The family medicine clerkship was chosen as the setting for the project because clerkship rotations are only four weeks long and send students to a variety of preceptors in geographically and socioeconomically diverse communities across the state of North Carolina. The study was submitted to Duke University's Institutional Review Board (IRB) and was declared exempt from IRB review.

The project involved six e-reader devices. For each clerkship rotation, two devices were sent to three separate locations, allowing one preceptor and one student at each site to test each e-reader for four weeks at a time. This allowed a comparison between clinical and educational use and provided a diverse pool of users from which to draw data. It also helped to build small communities of users—between the student and preceptor at each of the three sites—and among the students in each rotation.

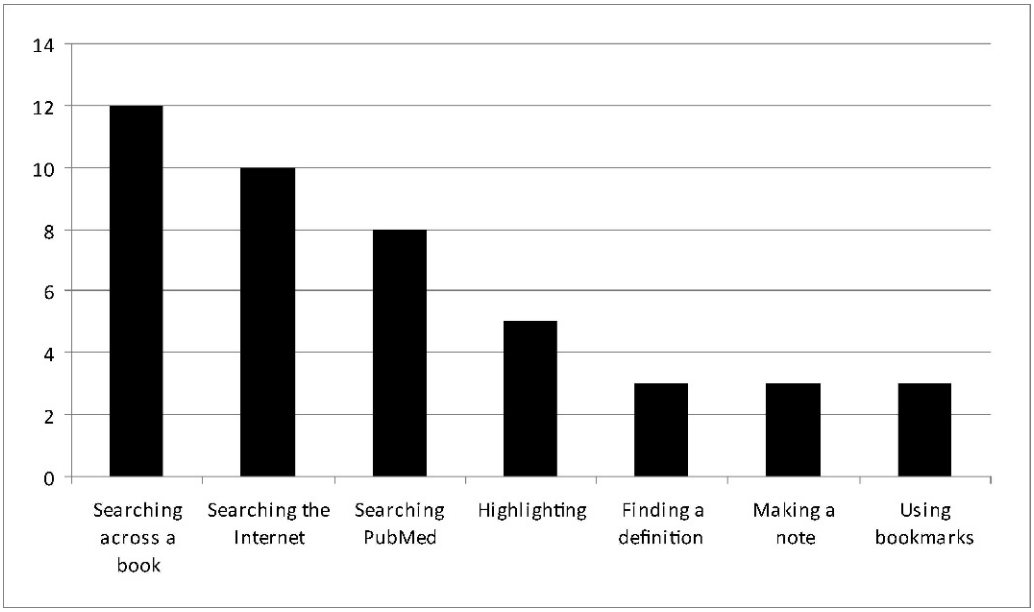
Methods

Six Kindle 2s were purchased and loaded with relevant material, including family medicine and primary care books sold through Amazon's Kindle store. Librarians identified relevant titles, and the clerkship director made the final selections. Due to Amazon's licensing agreements, which allow publishers to determine the number of Kindles on which each title can be viewed, some titles had to be purchased multiple times.

The family medicine clerkship director helped to identify practice guidelines that would be useful in the clinical setting, such as *Standards of Medical Care in Diabetes* and *The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7).* Because the project took place in 2009, before the software update that now allows Kindle 2s to display native portable document format (PDF) files, guidelines had to be converted to the Kindle format. Support documentation was also converted for the device, including the library's evidence-based medicine (EBM) toolkit, EBM glossary, tip sheets on searching PubMed, and information on the project. For some materials, such as the *Users' Guide to Evidence-based Practice*, librarians created a document on the Kindle menu that linked out to the full-text articles available online, a solution that allowed the use of existing web-based content and made it more accessible to users.

Before leaving Duke for their clerkship sites, students were informed of the research objectives and were trained by librarians in e-reader operations and availability of content. This training included how to use the device to search the PubMed for Handhelds interface. Students were expected to share this information with their preceptors once they were

Figure 1
Features used on the Kindle



at the clinics. This ''train-the-trainer'' approach was designed to help build the learning community among students and between students and their preceptors, and it gave students an incentive to pay attention to the training session, because they would have to become the trainer at their sites.

When each four-week rotation ended, students and preceptors were sent a link to an anonymous online survey asking them to rate the e-reader in terms of relevance of content, usability, efficiency, and appropriateness for various settings, including direct patient care (such as answering clinical questions in the examination room), indirect patient care (such as preparation for clinical work), educational support, and leisure reading (Appendix A, online only).

The project ran from April to December 2009 and included seven family medicine clerkship rotations. A total of fourteen preceptors and twenty medical students participated, representing primary care clinics from thirteen counties across North Carolina.

Results

Seven preceptors (a 50% response rate) and 15 students (a 75% response rate) completed the online survey evaluating the e-reader. Participants rated the e-reader favorably, with a majority rating it tolerable or terrific for size (10 tolerable, 8 terrific), weight (10 tolerable, 11 terrific), portability (10 tolerable, 11 terrific), reliability (10 tolerable, 12 terrific), and usability (15 tolerable, 4 terrific). It was rated poorly for speed, with 10 rating it terrible, 12 rating it tolerable, and none rating it terrific. The most popular features on the e-reader were searching across books and items, searching the Internet, and searching PubMed (Figure 1). Technical problems were rare, and 90% (19 out of 21) felt comfortable using it in front of colleagues.

Participants were encouraged, but not required, to use the e-reader during the 4-week rotation. Seventy-two percent of participants reported using the device in the clinical setting for indirect patient care (such as for preparation for clinical work), while only 8 used it for direct patient care (such as for answering clinical questions in the examination room). Only 6 students and preceptors used the device to answer a patient care question. Outside the clinical setting, 18 used it for educational support and 12 used it for recreational reading.

Not surprisingly, participant ratings of the e-reader's overall ease of use fell along similar lines. For use in the clinical setting, 17 rated the selected e-reader as tolerable (12) or terrific (5) for indirect patient care, while only 10 rated it as tolerable (9) or terrific (1) for direct patient care. A majority (11) rated it as terrible for direct patient care. For use outside the clinic, all 22 participants rated the e-reader as tolerable (15) or terrific (6) for educational support and 20 rated it tolerable (5) or terrific (15) for leisure reading.

Overall, 76% of participants (16 out of 21) did not recommend the selected e-reader for direct patient care, presumably due to low ratings for speed, which is important in the clinical setting. However, 81% (18 out of 21) either recommended or strongly recommended the e-reader for use in educational settings. One student noted that the e-reader shows ''great potential in educational setting[s], not so much in clinic probably given [the] potential for handheld devices such as iPhones. I think that the Kindle will be

a great investment once they increase processing power and make connecting to [I]nternet more user friendly.''

Further exploration of the data was done using multivariate pairwise correlations in JMP 8 software. One major difference found between preceptors and students was that preceptors were more likely than students to recommend the selected e-reader for direct patient care ($P<0.01$). A less significant but potentially instructive finding was that preceptors were also more likely than students to rate the device favorably for speed ($P<0.05$).

Other significant relationships were found between variables of usability, settings for use, and recommendations. Favorable ratings for usability in one setting were correlated with high usability ratings in other settings, specifically educational support and indirect patient care, and indirect patient care and direct patient care ($P<0.001$). Uses within the settings were also correlated: Those who used the selected e-reader for leisure reading were likely to use it for educational support, and those who used it for indirect patient care were also likely to use it for direct patient care ($P<0.01$).

Those who used the e-reader were also more likely to recommend it and rate it favorably. Use of the device for educational support was correlated with recommending it for use in both the educational and clinical care settings ($P<0.01$). Use of the device in indirect patient care settings was correlated with favorable ratings for weight, use in educational support was correlated with favorable ratings for size, and use in leisure reading was correlated with favorable ratings for usability (all $P<0.01$). There were also correlations between favorable ratings for weight, size, and portability ($P<0.01$).

TEXAS A&M UNIVERSITY MEDICAL SCIENCES LIBRARY

Methods

The TAMU MSL is 1 of 5 libraries located on the campus at College Station, Texas. Spread over 5,000 acres, the campus enrolls more than 47,000 students. The MSL houses 120,000 print titles and 1,600 serials, with a collection budget of more than $1.8 million. Through the main library's subscriptions, MSL users have access to more than 400,000 e-books. The library supports the TAMU College of Veterinary Medicine and Biomedical Sciences, TAMU College of Agriculture and Life Sciences, and Texas A&M Health Sciences Center (TAMHSC). TAMHSC includes the TAMHSC College of Medicine, College of Nursing, Graduate School of Biomedical Sciences, Rangel College of Pharmacy, and School of Rural Public Health. For the purposes of this study, librarians chose to target the college of medicine's residents and 4th-year students.

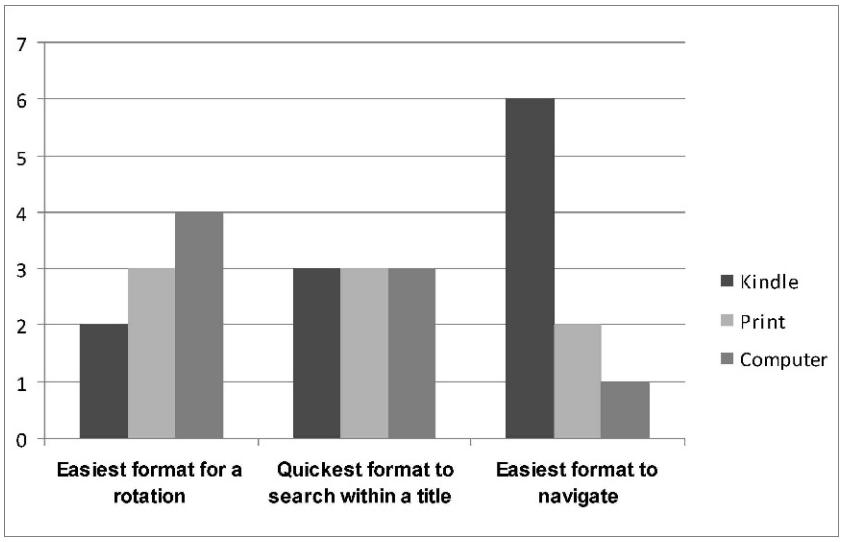
The MSL conducted a three-month, qualitative project with fourth-year medical students and residents to evaluate how the Kindle e-reader could support learning in primary care. The project objective was for users to determine if medical textbooks on the selected e-reader provided advantages beyond those of print or online texts in clinical settings. The library funded the purchase of six e-reader devices and medical titles. One librarian taught a fourth-year elective, in which students evaluated electronic resources. E-reader evaluation was offered as an optional learning module in this elective. Volunteers were solicited from residents attending morning report at a local hospital. Study approval and exempt status was received from TAMU's Institutional Review Board.

Six original Kindles were purchased and each loaded with e-books from Amazon's Kindle store. Because the MSL's study focused on format preference, e-reader titles were selected based on availability in print and online to MSL users. The twelve medical textbooks selected for the project included core titles, such as *Harrison's Principles of Internal Medicine* and *Principles of Critical Care,* as well as rotation-specific titles such as *Current Diagnosis & Treatment in Family Medicine*. Due to Amazon licensing agreements, the same title could only be loaded on three of the six devices.

Fourth-year students. Librarians focused first on students due to the timing of the elective and a limited number of e-readers. The fourth-year elective consisted of self-paced modules, so librarians created a self-guided e-reader exercise. Nine fourth-year medical students from June to July 2009 completed the exercise. Students were given the study objectives and directed to an online Amazon Kindle tutorial to learn to use the device. The exercise instructed students to explore Amazon's list of Kindle medical textbooks to compare prices of print and e-reader titles. Then students chose two titles loaded on their device to compare to the print and online versions. The exercise asked how easy it was to learn to use the e-reader and to compare the advantages and disadvantages of the three formats. Both the e-reader and the print versions of the texts were held on reserve at the students' learning resource center. All data were stripped of identification before submission to the primary investigator for compilation into Excel spreadsheets.

Residents. The same e-readers and e-books were used with the residents. In August 2009, six residents accepted the three-week loan of an e-reader. Participants were given a document with research objectives and the link to the Amazon Kindle instructional video. Residents were told to use the e-reader as much or as little as they desired during the three weeks. Once residents returned the device, they were sent an email with a link to an anonymous online survey link. The eight-question survey asked residents about their e-reader use, including frequency, setting, purpose, and their preferred source to answer clinical questions (Appendix B, online only).

Figure 2
Student format preferences



Results

Fourth-year students. After comparing prices of e-reader and print titles, some students commented that e-reader titles were less expensive, compared to print. Six out of 9 students were interested in the e-reader version of United States Medical Licensing Examination (USMLE) study guides. The titles that the students chose to evaluate varied according to their rotation. More than half (5/9) of the students chose *Harrison's Principles of Internal Medicine*. Three students each chose to evaluate *Clinical Neurology*, *DeGowin's Diagnostic Examination*, *Current Diagnosis & Treatment in Orthopedics,* and *Pathophysiology of Disease: An Introduction to Clinical Medicine.*

The majority of students (6/9) rated the e-reader very easy to fairly easy to learn. Students were, however, just as comfortable accessing e-books online. Navigation, portability, and searchability affected students' format preferences. Six students found the e-reader the easiest format to navigate, while two chose print and one chose online e-books (Figure 2). Only a couple of students found the e-reader to be the easiest format to use specifically for rotations (Figure 2). These students noted the device's light weight, portability, and small size. One student explained, ''On rotations you need something small enough to fit in a white coat pocket. On all of my rotations I looked for a study book that I could easily carry and pull out when there is downtime. The [K]indle is the only one that will fit and it is very useable.'' In terms of searchability, students were evenly divided between the three formats (Figure 2). Some students still preferred searching using the table of contents and index in the print title. Other students mentioned the e-reader's search function and built-in dictionary: ''What is nice about [the K]indle is that you are able to use the dictionary about any word on the page. Also when you search on [the K]indle it searches every book on the device at the same time.''

Disadvantages of e-readers focused on attributes of the display. About half of students (4/9) pointed out that not having a color display when viewing medical illustrations was a great disadvantage. Also, three students complained that it was difficult to tell how far they were into the text, compared to print or online books. Some students suggested that these limitations would be mitigated if the e-readers were used to access USMLE study guides and pharmacology flashcards.

Overall for clinical settings, none of the students preferred the selected e-reader. Those who preferred print books explained that they liked being able to highlight in and resell the book or that reading on a computer screen for long periods hurt their eyes. Another student who preferred print books complained that the e-reader had to be charged and that it was ''another thing to carry, not intuitive [and the] pictures are really small.'' Because computers were available throughout the hospital, about half the students (6/9) found online text most preferable. As one student mentioned, with online text they could ''easily see all headings and chapters of the book on one screen, [and] the book even has the subheadings on the first page so you can easily identify the part of the chapter you are interested in reading.'' Some students preferred different formats for different settings: ''If at the hospital I would rather use the eBook version. But if I am at home it would be easier to walk over and open the print version. The problem there is that no one could buy all of the possible books that they may eventually reference.''

Residents. All six residents who borrowed an e-reader completed the online survey. Not all participants answered each question. Residents were asked how often they used the device during the three

weeks. One resident claimed to have used the e-reader only once, three used it a few times, and two said they used it daily. In terms of difficulty using the device, one resident found it somewhat difficult to use, one neither difficult nor easy, three found it somewhat easy to use, and one skipped the question. Interestingly, none of the residents said they used the e-reader at the hospital.

When asked how long it took on average to answer a clinical question using the e-reader, one resident responded with less than fifteen minutes and two with fifteen minutes, two said they did not find the answer to any clinical questions using the device, and one skipped the question. When asked if they would advocate using the selected e-reader in clinical settings, two residents said they would recommend it, two said they would not, and two skipped the question.

Half of residents (3/6) preferred to find clinical answers using online resources, such as UpToDate, Epocrates, and the American Academy of Family Physicians (AAFP) website. One resident preferred the e-reader, and two residents did not respond to this question. Three residents made additional comments. One said that a ''Kindle would be nice for sitting down to read, but not as a quick reference in a clinical setting.'' Another said that the e-reader ''is much better than the text books but inferior to online resources like [U]ptodate [and AAFP]. I would use [a K]indle in place of text books. It is easy to carry and use.'' The third resident said, ''[I]t's a great reading device. However, it needs better resolution display and color, as well.''

DISCUSSION

The two studies offer some insight into the potential role for e-readers in medical education. While disparate evaluation instruments were used in the studies, similar themes emerged from the results. Participants from both studies rated the selected e-reader as highly portable, overcoming accessibility issues that might arise in clinical settings, but users found limitations in the e-reader's navigation, lack of color display, and speed. The e-reader processor and wireless connection were slow for use in direct patient care settings, especially when networked computers were available. In the clinical setting, computers were easier to use and faster than the e-reader for answering patient care questions, and participants from both studies reported preferring computer-based online resources to those on the e-reader.

Participants from both studies suggest that e-readers still have a place in medical education. Students and preceptors from the Duke project recommended the device for academic purposes such as reading through practice guidelines or a textbook in preparing for or after seeing a patient. Some students also reported listening to e-books through the device's ''Text-to-Speech'' feature while driving to their clerkship rotations. Residents and students in the TAMU study suggested that the device would be more useful as a recreational reader or as a study guide.

Future developments

Duke University Medical Center Library and TAMU MSL both now circulate e-readers. Duke maintains a variety of resources on the device, from textbooks to recreational reading, to appeal to students, faculty, and medical center staff. It plans to continue testing the e-reader in lower resource environments that lack networked computers or wireless devices, including global health field sites.

In May 2010, librarians at TAMU implemented students' suggestions to utilize the Kindle as a study guide and began to circulate Kindles to second-year medical students preparing for the USMLE. The six e-readers were loaded with study guides and pharmacology flashcards and marketed to second-year medical students studying for the USMLE. While little input has yet been gathered from these students, circulation records show that the devices were quickly checked out and remained checked out for several weeks. Future plans include adding more study guides and flashcards available on the e-reader for other user groups.

Study limitations

Limitations of both studies included the small sample sizes. Also, while both projects were exploratory and gathered feedback on use and preferences, it is difficult to combine the studies' results because they had distinct project designs and evaluation instruments.

A primary objective of the Duke project was to test the selected e-reader in low resource settings, but due to preceptor availability and scheduling issues, most of the community clinics involved in the family medicine clerkships during the project period offered networked computers and wireless access. This might have negatively impacted the role for and use of the e-reader. Materials selected for the devices were not required reading, and it was possible that students and preceptors did not have time for extra reading.

At TAMU, the e-readers used were original Kindles. Study feedback might have changed if Kindle 2s had been used, as navigation issues cited by participants were improved in the next version of Kindle. Another factor that could have impacted feedback was that, due to licensing issues, only three copies of each medical textbook could be downloaded, so not all participants had access to the same titles. Kindle titles might also not have been relevant to the participants' clinical work during the time of evaluation. In addition, the students' exercise and the residents' survey asked different questions, making some data comparison difficult. No input was gathered from first-, second-, and third-year medical students who might have different perspectives and needs than fourth-year students and residents.

CONCLUSIONS

The purpose of the two projects was to explore how medical libraries could utilize e-readers to support medical education in clinical settings. While the two

projects had different foci, methods, and collected data and used different versions of the Kindle, both Duke's and TAMU's projects illustrate that the Kindle e-reader's major advantages when used in clinical settings are its portability and the ability to search within and across books. The studies also indicate that the selected e-reader is limited when used to answer clinical questions because of slow connection speed, suboptimal navigation, and black-and-white display. These limitations may be overcome as e-readers are further developed. The studies were designed when the Kindle was one of two e-readers on the market and the only one to offer free wireless (through the Kindles 1, 2, and the 3G models). As e-readers continue to evolve and as new devices become available, librarians will face numerous options and a rapidly changing e-reader marketplace. Rather than focusing on single devices, librarians should determine the features that are most important to their library patrons. From the results of these studies, the authors identified five features that participants clearly valued in a clinical setting, judging from the participants' positive and negative feedback: portability, searchability, speed, navigation, and display. Librarians planning to purchase e-readers for their institutions should consider these five criteria when evaluating what is available at their time of purchase. They should also consider the setting in which the devices will be used.

More research and case studies are needed to investigate the functionality of other devices in clinical settings. Additionally, research should be performed comparing e-readers with various currently available PDA and smart phone devices. Exploring the difference between e-readers and mobile devices in clinical settings may also provide new insights into the best tools to support clinical education.

Medical libraries provide access to information to facilitate clinical care, education, and research. As new devices and technologies become available, an emerging role for libraries is determining how these tools might benefit users and be used to develop additional or improved library services. Defining the scope of this role can be difficult as patrons' needs vary, devices can be costly, and new models are frequently released. While some users may appreciate the opportunity to try new resources at a library before purchasing the resource themselves, others may seek out training or additional library content for a device. The role of libraries in exploring how these devices may be utilized will undoubtedly continue to evolve and merits future discussion.

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